Aquatic Vegetation of Big Pine Lake

August, 2013

Big Pine Lake, ID# 01-0157-00

Aitkin County, Minnesota

Three-square bulrush stands in Big Pine Lake, August 2013.

MNDNR

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SUMMARY

Aquatic and shoreline vegetation surveys of Big Pine Lake (01-0157-00), Aitkin County, Minnesota, were conducted in August of 2013. Three lake habitat zones were assessed: the shore, the nearshore, and the in-lake plant communities. Surveys included characterization of shore habitat and nearshore plant communities at 54 sites, delineation of all emergent and floating-leaf plant stands, and quantitative assessments of submerged plant communities at 300 sample stations within the shore to 20 feet depth.

The majority (80%) of Big Pine Lake shore sites were classified as developed. On a scale of 0 to 100, the mean lakewide shore habitat score was 60, indicating that almost half of the shore habitat has been lost. Most developed sites had few or no remaining trees, shrubs and/or natural ground cover compared to undeveloped sites where these plants were present along the entire shore frontage.

Aquatic plants were distributed around the perimeter of Big Pine Lake and 90% of all in-lake sample sites contained vegetation. Forty-seven aquatic plant taxa were found including 11 emergent, five floating-leaved, two free-floating and 26 submerged taxa.

Emergent and floating-leaved plants occurred in shallow water (0-5 feet deep) and occupied 50 acres within that depth zone. Approximately 27 acres of bulrush (*Schoenoplectus* sp.) beds were delineated. Floating-leaf plants covered about 22 acres and included white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*), and floating-leaf pondweed (*Potamogeton natans*).

Submerged plants were found to a maximum depth of 22 feet but were most frequent in depths from shore to 15 feet, where 62% of the sites contained at least one submerged species. The most common submerged plant species were muskgrass (*Chara* sp.) (39% occurrence within the shore to 20 feet zone), coontail (*Ceratophyllum demersum*) (37%), northern watermilfoil (*Myriophyllum sibiricum*) (36%), flat-stem pondweed (*Potamogeton zosteriformis*) (36%), narrow-leaf pondweed (*Potamogeton* spp.) (34%), clasping-leaf pondweed (*Potamogeton richardsonii*) (20%) and wild celery (*Vallisneria americana*) (24%). One non-native plant taxa; curly-leaf pondweed (*Potamogeton crispus*) was found growing in the lake.

Nearshore sites contained highest diversity and sites of high richness (6 or more taxa per site) often occurred in depths less than 10 feet and included sites where emergent and submerged plants co-occurred. All of the plant taxa found in the lake occurred in this shallow zone.

The abundance and diversity of native plants, including the extensive beds of emergent and floating-leaf plants and mixture of many types of submerged plants, help maintain high water clarity and provide critical habitat for fish and wildlife in this lake.

INTRODUCTION

Lake location and characteristics

Big Pine Lake is in the Laurentian Mixed Forest Province of north central Minnesota, about five miles north of Garrison in Aitkin County (Map 1). This region of the state is characterized by broad areas of conifer forest, mixed hardwood and conifer forests, and conifer bogs and swamps with numerous glacial lakes. Big Pine lies at the top of the Rum River watershed. It is a flow-through lake that receives inflow from an unknown stream from the northwest and southeast. The lake outflows from the southwest to Round Lake (Map 1). An unnamed stream flows south through Borden Lake and runs into the Rum River which continues south to join the Mississippi River.

Big Pine Lake has a surface area of 635 acres, is the 15th largest lake in Aitkin County and the 8th largest lake in the watershed. The lake has an irregular outline with several islands and a total of five miles of shoreline. The shoreline is developed with residential homes. The State of Minnesota maintains a public access on the southwest side of the lake (Map 2).

Big Pine Lake has a maximum depth of 78 feet but about 41% of the lake is 15 feet or less in depth (Map 2). The lake is a hard water lake and is characterized as mesotrophic, based on phosphorus (nutrients), chlorophyll-a (algae concentration) and Secchi depth (transparency). The 2005 to 2013 mean summer water clarity was 13 feet (MPCA 2014). Based on Secchi disk measurements alone, aquatic plants have the potential to reach depths of about 20 feet in the lake. Other factors that may influence the depth of plant growth include substrate, wind fetch and the types of plants present.

Historical aquatic plant community

Seven previous aquatic plant surveys of Big Pine Lake were conducted between 1941 and 1996 (MNDNR Lake files). These surveys varied in methods; the earliest surveys focused on the commonly occurring in-lake plants while the 1995 survey included a detailed listing of any plant taxa encountered by an experienced botanist. The areas of the lake surveyed and the surveyor's botanical experience influence the number and types of plants detected in each survey. Data from these surveys were compiled and compared to recent data collected in 2013.

Survey objectives

The 2013 surveys assessed three habitat zones of Big Pine Lake: the shore, the near-shore area, and the lakewide plant community. Specific objectives included:

1. Estimate the remaining shore habitat on a scale of 0 to 100.
2. Describe the types and general distribution of plants in the lake.
3. Describe and map the emergent and floating-leaf plant stands.
4. Estimate the abundance of aquatic plants by estimating the frequency of occurrence of all plants and each taxon within the vegetated zone.

METHODS

In 2013, four different methods were used to survey the different plant and habitat zones of Big Pine Lake. Survey methods are described in the MDNR Lake Plant Survey Manual (Perleberg et al. 2016).

Shore habitat assessment

The shoreline habitat of Big Pine Lake was assessed using the "Score the Shore" method (Perleberg et al. 2016). Survey sites were established every 200 meters along the shoreline and corresponded to the nearshore aquatic plant survey sites (Map 3). Surveys were conducted on May 28th by boat and at each site; surveyors visually assessed 100 feet of shoreline. Habitat features were assessed in the Shoreland, Shoreline and Aquatic zones and included tree cover, shrub cover, natural ground cover, overhanging vegetation, woody habitat. Disturbance to habitat was assessed by noting the presence of artificial openings in aquatic plant stands and the presence of human structures such as docks. Sites with a high percentage or tree, shrub and natural ground cover and with little or no human disturbance receive higher scores than sites where vegetation has been removed.

Mapping floating-leaf and emergent vegetation beds

Mapping focused on emergent and floating-leaf plant stands that were at least 0.01 acres, or about 400 square feet, in size (generally larger than the surface area covered by a pontoon boat). Field surveys were conducted August 22, 2013 to map plants like bulrush (*Schoenoplectus* spp.), which are difficult to identify from aerial photos, and to verify photo-interpretation of other plant beds. Surveyors' mapped emergent and floating-leaf plant stands in the field by motoring or wading around the perimeter of each stand and recording a track with a handheld Global Positioning System (GPS) unit. Field data were uploaded to a computer and a Geographic Information System (GIS) software program was used to estimate acreage. Plant beds were classified by the dominant species or species-group (Table 1).

Table 1. Classes of emergent and floating-leaf plant stands

Class	Dominant Species
Rushes	Bulrush (*Schoenoplectus*) or Spikerush (*Eleocharis*)
Rushes and other	Bulrush (*Schoenoplectus*) or Spikerush (*Eleocharis*) and other common taxa
Waterlilies	White waterlily (*Nymphaea*) or Yellow waterlily (*Nuphar*)
Waterlilies and other	White waterlily (*Nymphaea*) or Yellow waterlily (*Nuphar*) and other common taxa
Wild Rice	Wild rice (*Zizania palustris*)
Cattail	*Typha* spp.
Other emergent	Ex. arrowhead (*Sagittaria*), giant cane (*Phragmites*)

2013 lakewide vegetation survey (point-intercept)

A lakewide vegetation survey was conducted on August 12-14, 22, 28, 2013 using a point-intercept survey method (Perleberg et al. 2016, Madsen 1999). Survey waypoints were created using a GIS computer program and downloaded into a handheld GPS unit. Sample methodology

requires that a minimum of 100 points be sampled to estimate the frequency of occurrence of the most common taxa. Survey points were placed in a grid pattern and were spaced 65 meters (213 feet) apart (Map 3).

The survey was conducted by boat and a GPS unit was used to navigate to each sample point. One side of the boat was designated as the sampling area. At each site, water depth was recorded in one-foot increments using a measured stick in water depths less than seven feet and an electronic depth finder in deeper water. In preliminary sampling of water depths of 21 to 25 feet, surveyors detected only one vegetated site and therefore decided to not sample additional sites in those depths. Surveyors attempted to sample all sites in water depths less than 21 feet for a total of 300 samples in that zone (Table 2).

Substrate sampling

At each sample site where water depths were seven feet and less, surveyors described the bottom substrate using standard substrate classes (Table 3). Surveyors evaluated substrate by tapping a pole into the lake bottom; soft substrate could usually be brought to the surface on the pole or sampling rake for evaluation. If this method was not feasible, substrate was evaluated by visual observation of the lake bottom. If more than one substrate type was found, surveyors recorded the most common type. Surveyors attempted to record a substrate description around the entire perimeter of the lake. If a sample site occurred near shore but in water depths greater than seven feet, surveyors collected depth and vegetation data and then motored into shallower water and recorded the substrate type adjacent to the actual survey point; this information was used for mapping purposes.

Table 2. Survey effort by water depth

Water depth (feet)	Number of survey sites
0 to 5	149
6 to 10	91
11 to 15	21
16 to 20	38
Total	300
21 to 25	21

Table 3. Substrate classes

muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	diameter < 1/8 inch
gravel	diameter 1/8 - 3 inches
rubble	diameter 3 - 10 inches
boulder	diameter > 10 inches

Plant sampling

Photo 1. Sample Rake.

Surveyors recorded all plant taxa found at each sample site (approximately a one square meter sample site at the pre-designated side of the boat). A double-headed, weighted garden rake, attached to a rope was used to survey vegetation not visible from the water surface (Photo 1). Any additional plant taxa found outside of sample sites were recorded as "present" in the lake but these data were not used in frequency of occurrence calculations. Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MnTaxa (2013). Frequency of occurrence was calculated for the entire vegetated zone (0-20 feet) and data were also separated into five feet increment depth zones for analysis (Table 2). Frequency estimates were also calculated for individual taxa and selected groups of plants.

2013 Near-shore plant community assessments (plots)

Because the point-intercept method may under sample near-shore plant zone, additional surveys were conducted at the shore-water interface (or near-shore) zone of Big Pine Lake. Survey waypoints were created using a GIS computer program. Sample sites were spaced 200 meters apart along the shoreline for a total of 54 sites (Map 3). At each site, surveyors sampled a plot area measuring approximately 5 meters along the shore and extending 5 meters lakeward. Surveyors waded through the plot and recorded all plant taxa observed; view tubes were used to aid in visual observation of plants. Water depth at the center of the plot was recorded and substrate was described using classes in Table 3.

RESULTS AND DISCUSSION

Shore habitat

Shore habitat was assessed at 54 sites around the lake the mean habitat score was 60.0 which is considered low on the overall scale from 0 to 100. Eighty percent of sites were classified as developed including 33 sites with a single residential home, 9 sites with more than one residential home, and one roadway site. Developed sites were evenly distributed around the lake and had a mean score of 35.6 compared to undeveloped sites which had a mean score of 92.4. Developed sites scored lower than undeveloped sites, particularly in the Shoreline and Shoreland Zones where trees, shrubs and/or natural ground cover had been removed.

The shore habitat of Big Pine Lake ranks lower than other Minnesota lakes where shore habitat has been assessed; statewide the mean shore habitat score is 74. Within the Rum River watershed, Big Pine Lake shore habitat score is lower than the mean score from other lakes (Table 4).

Table 4. Comparison of Big Pine Lake Shore Habitat with other lakes

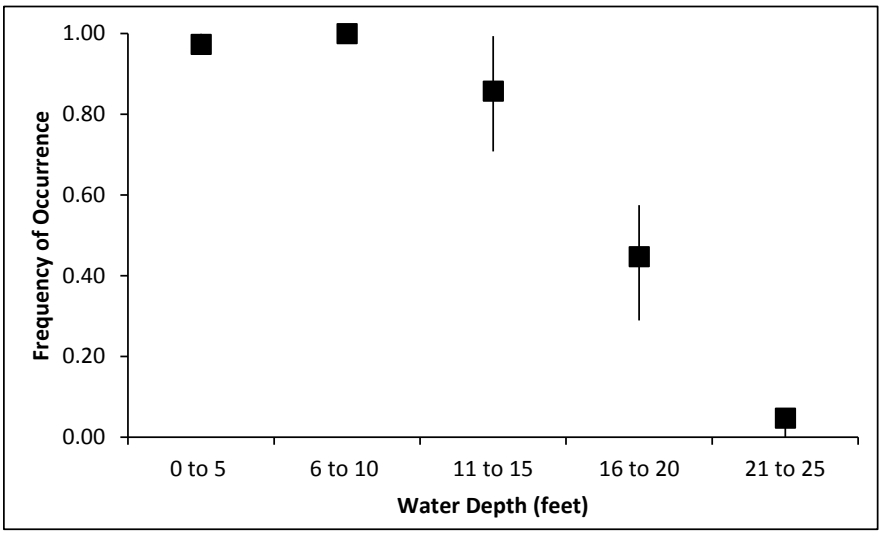
	Aquatic Score	Shoreline Score	Shoreland Score	Lakewide Total Score
Mean score for Big Pine	25.4	18.3	16.7	60.4
Mean score from other lakes in Rum River watershed	26.0	20.5	19.2	65.7
Mean score from other lakes in State	25.8	24.4	23.8	74.0

In-lake habitat

The near-shore substrates of Big Pine Lake included a mix of hard substrates (boulder, rubble, sand and gravel) and soft substrates (silt, marl and muck) (Map 4). Sand dominated the substrate and was found in half of the shallow sites. Softer substrates occurred in protected bays.

Plants were found to a depth of 22 feet in Big Pine Lake but were very sparse in depths greater than 20 feet. Frequency estimates are provided for sites within the 0 to 20 feet depth zone where 71% of the survey sites contained vegetation (Map 5). Vegetation was most common in the shore to 10 feet depth zone, where nearly 100% of sites contained plants (Figure 1). Plant abundance declined with increasing water depth and in depths of 16 to 20 feet, 47% of the sites were vegetated; vegetation was detected in only 5% of sites in the 21 to 25 feet zone.

Figure 1. Percent vegetated sites vs. water depth



Aquatic plant diversity

A total of 47 aquatic plant taxa (types) were recorded in Big Pine Lake. The plants included 14 emergent, five floating-leaved, two free-floating and 26 submerged plants (Table 5). Three of these taxa (narrow-leaf water plantain (*Alisma gramineum*), broad-leaf arrowhead (*Sagittaria latifolia*), and southern naiad (*Najas guadalupensis*)) were recorded for the first time during the 2013 survey. These plants are all native to central Minnesota and were likely present during earlier surveys of Big Pine Lake but went undetected. Some of these plants are difficult to distinguish from closely related plants; others may have been missed if they were present in low numbers.

All aquatic plants observed in Big Pine Lake in 2013 are native to Minnesota with the exception of the submerged plant curly-leaf pondweed (*Potamogeton crispus*). Non-native terrestrial and wetland plants were present along the shore and included reed canary grass (*Phalaris* sp.) and Kentucky bluegrass (*Poa* sp.).

The highest number of plant taxa was found in shallow water, in depths less than 11 feet. The number of plant taxa found at each sample site ranged from 0 to 15 with a mean of three species per site. Sites of high species richness (6 or more taxa per site) often occurred in depths less than 10 feet and included sites of where emergent, floating-leaf and submerged plants co-occurred (Map 6).

Emergent and floating-leaf plant stands

Emergent and floating-leaf plants were restricted to shallow water of Big Pine Lake and within the 0 to 5 feet depth zone, they occupied 50 acres (Map 7). Emergent plant stands were primarily found on the west, southwest and east shores and only 38% of the shore sites contained these plant stands.

Bulrush (*Schoenoplectus* spp.) occupied about 27 acres and was found on sandy sites in water depths from shore to five feet. Bulrush is an emergent, perennial plant that is rooted in the lake bottom with narrow stems that may extend several feet above the water. In addition to providing valuable fish and wildlife habitat, the extensive root network of these plants help to stabilize sandy shorelines. In shallow water, they may spread by underground rhizomes but these plants are particularly susceptible to destruction by direct cutting by human, motorboat activity and excess herbivory. Restoration of bulrush stands can be very difficult, making established stands particularly unique and valuable.

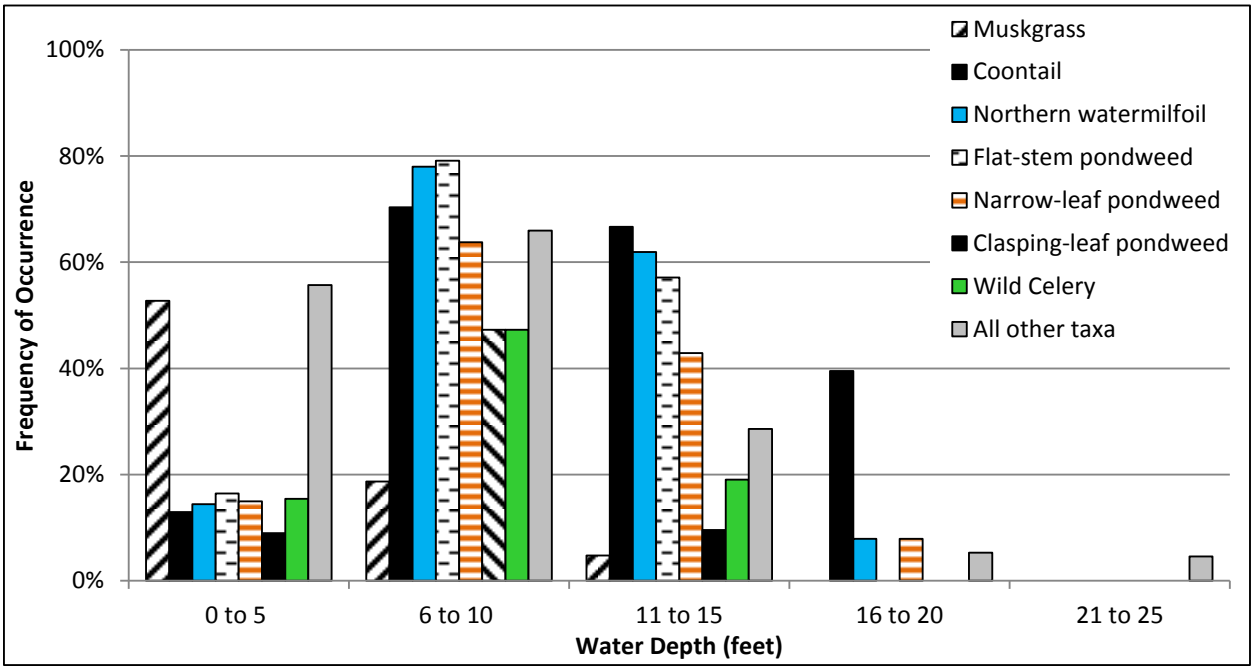
Twenty-two acres of "Waterlilies and Waterlilies and Others" were mapped and were dominated by floating-leaf plants such as white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*), floating-leaf smartweed (*Persicaria amphibian*), watershield (*Brasenia schreberi*) and floating-leaf pondweed (*Potamogeton natans*). Waterlily stands often contained scattered emergent plants such as arrowhead, bulrush and submerged plants. The floating leaves of waterlilies provide shade and shelter for fish, frogs and invertebrates. The showy

flowers produce seeds that are eaten by waterfowl and the rhizome are a food source for muskrats and deer (Borman et al. 2001).

Submerged plants of Big Pine Lake

Lakewide, submerged plants were the most common type of vegetation and were found in 70% of all sites sampled, 62% of all of the Point-Intercept (rake toss) sample sites and in 79% of the nearshore plots. The most frequently occurring taxa were muskgrass (*Chara* sp) (39%), coontail (*Ceratophyllum demersum*) (37%), northern watermilfoil (*Myriophyllum sibiricum*) (36%), flat-stem pondweed (*Potamogeton zosteriformis*) (36%), narrow-leaf pondweed (*Potamogeton* spp.) (34%), clasping-leaf pondweed (*Potamogeton richardsonii*) (20%), and wild celery (*Vallisneria americana*) (24%). All other taxa occurred in less than 20% of the sample sites. Each plant taxa varied in frequency within each depth zone (Figure 2).

Figure 2. Common submerged aquatic plants in Big Pine Lake, 2013.



Muskgrass (*Chara* sp.) is a freshwater macroalgae and is common in many hard water Minnesota lakes. It has a brittle texture and a characteristic "musky" odor. Because muskgrass does not form true stems, it is a low-growing plant, often found entirely beneath the water surface where it may form low "carpets" on the lake bottom (Photo 2). Muskgrass is adapted to variety of substrates, can withstand heavier wave action than can rooted plants, and is often the first plant to colonize open areas of lake bottom where it can act as a sediment stabilizer. Beds of muskgrass can provide important fish spawning and nesting habitat. Muskgrass dominated the submerged plant community in Big Pine Lake, occurring in

Photo 2. Muskgrass

39% of the survey sites (Table 5). It was the most frequent plant in the 6 to 15 feet depth zone (Figure 2).

Photo 3. Northern watermilfoil

Watermilfoils are mostly submerged rooted perennial plants with finely dissected, "feather-shaped" leaves. There are several native species of watermilfoils in Minnesota and these plants are not tolerant of turbidity (Nichols 1999) and grow best in clear water lakes. Particularly in depths less than 10 feet, watermilfoils may reach the water surface and their flower stalk will extend above the water surface (Photo 3). They spread primarily by stem fragments and over-winters by hardy rootstalks and winter buds. Northern watermilfoil (Myriophyllum sibiricum) was the only watermilfoil found in Big Pine Lake. It was found in 36% of all sites (Table 5), occurred to a depth of 19 feet and was most common in the 6 to 10 feet depth zone (Figure 2).

Pondweeds (*Potamogeton* spp. and *Stuckenia* spp.) are primarily submerged, perennial plants that are anchored to the lake bottom by underground rhizomes. Depending on water clarity and depth, these plants may reach the water surface and may produce flowers that extend above the water. Pondweed seeds and tubers are an important source of waterfowl food (Fassett 1957) and the foliage of pondweeds is food for a variety of marsh birds, shore birds and wildlife and provides shelter, shade and spawning sites for a range of fish species (Borman et al. 2001).

Photo 4. Flat-stem pondweed.

Flat-stem pondweed (*Potamogeton zosteriformis*) was found in 36% of the samples sites (Table 5). This plant can grow at a variety of water depths and can over-winter by rhizome and winter buds. In Big Pine Lake, flat-stem pondweed was common at all water depths between shore and 15 feet depth and reached its peak at depths of 6 to 10 feet (Figure 2). Flat-stem pondweed was often found growing in mixed stands with a variety of other submerged species (Photo 4).

Photo 5. Sago pondweed

Narrow-leaf pondweeds occurred in 34% of the survey sites (Table 5). They were found to a depth of 17 feet and within the 6 to 10 feet depth zone they occurred in about 66% of the sites (Figure 2). These include taxa that can be difficult to identify if not found in flower or fruit. Fries' pondweed (*Potamogeton friesii*), small pondweed (*P. pusillus*), and sago pondweed (*Stuckenia pectinata*; Photo 5) were positively identified in the lake, but additional narrow-leaf species may have also been present.

Clasping-leaf pondweed (*Potamogeton richardsonii*; Photo 6) occurred in 20% of the sites between shore to 20 feet (Table 5). This plant has alternate leaves with a prominent midvein, wavy leaves and comes to a sharp point. Leaves clasp the stem and have fibrous stipules. It frequently occurred in depths from 6 to 10 feet (Figure 2).

Photo 6. Clasping-leaf pondweed.

Wild celery (*Vallisneria americana*; Photo 7) occurred in 20% of the sites between shore and 20 feet (Table 5). This submerged, grass-like species prefers hard substrates. It occurred around the entire lake and was most common in depths less than 11 feet (Figure 2).

Photo 7. Wild celery

Aquatic plant community dynamics

Big Pine Lake supports an excellent diversity of native plant communities that provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants). The types and amounts of aquatic plants are influenced by a variety of factors including water clarity, water chemistry, depth, substrate type and wave activity. Within lake differences in these physical features as well as different levels of human activity can result in different types and amounts of vegetation.

The 2013 survey provides a snapshot of the Big Pine Lake plant communities and there may be a year to year difference in amounts and types of plants present in the lake. The annual abundance, distribution and composition of aquatic plant communities may change annually due to environmental factors and the specific phenology of each plant species. Monitoring change in the aquatic plant community can be helpful in determining whether changes in the lake water quality are occurring and for estimating the quality of vegetation habitat available for fish and wildlife communities. Data collected in 2013 can be used to monitor finer-scale changes that may occur, such as an increase in a particular species, loss of species, or changes in the depths at which individual species occur.

Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. The results of these control activities can be difficult to predict and should be conducted with caution to reduce potential negative impacts to non-target species. Motorboat activity in vegetated areas can be particularly harmful for taxa such as bulrush. Shoreline and watershed development can also indirectly influence aquatic plant growth if it results in changes to the overall water quality and clarity. For information on the laws pertaining to aquatic plant management: MNDNR APM Program.

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TABLE 5. HISTORIC AND CURRENT PLANTS OF BIG PINE LAKE

Wetland emergent plants

Common Name	Scientific Name	1941	1946	1956	1970	1991	1995	1996	2013 LW	2013 NS
Iris	*Iris* sp.								--	2
Reed canary grass (I)	*Phalaris arundinaceae*								<1	2
Common reedgrass	*Phragmites australis*		X					R	P	--
	Total	0	1	0	0	0	0	1	2	2

Emergent plants

Common Name	Scientific Name	1941	1946	1956	1970	1991	1995	1996	2013 LW	2013 NS
Narrow-leaf water plantain	*Alisma gramineum*								2	12
Sedge	*Carex* sp.		X			O		R	1	4
Water arum	*Calla palustris*					R		R	--	2
Spikerush	*Eleocharis palustris*						X	R	<1	--
Horsetail	*Equisetum fluviatile*	C					X		<1	2
Pickerelweed	*Pontederia cordata*	C	X						--	--
Stiff wapato	*Sagittaria rigida*					C	X	R	1	8
Broad-leaf arrowhead	*Sagittaria latifolia*								P	--
Arrowhead	*Sagittaria* sp.		X					R	1	8
Three-square bulrush	*Schoenoplectus pungens*	C					X		1	2
Bulrush	*Schoenoplectus* sp.	C	X	C	C	C	X	R	5	6
Giant burreed	*Sparganium eurycarpum*					R	B[1]		B[1]	4
Narrow-leaf cattail	*Typha angustifolia*			C	O			R	<1	6
Broad-leaf cattail	*Typha latifolia*		X			O			--	2
Wild rice	*Zizania palustris*							R	P	--
	Total	4	5	2	2	6	6	8	12	11

Table 5: Historic and current plants of Big Pine Lake (continued)

Floating-leaved plants

Common Name	Scientific Name	1941	1946	1956	1970	1991	1995	1996	2013 LW	2013 NS
Watershield	*Brasenia schreberi*		X			O		R	3	4
White waterlily	*Nymphaea odorata*	C	X	C		O		R	3	12
Yellow waterlily	*Nuphar variegata*	C	X	C	O	O	X	R	2	2
Floating-leaf smartweed	*Persicaria amphibian*		X			O		R	2	2
Floating-leaf pondweed	*Potamogeton natans*	A	X	C		O	X	R	<1	6
Floating-leaf burreed	*Sparganium* sp.							R	--	--
	Total	3	5	3	1	5	2	6	5	5

Free-floating plants

Common Name	Scientific Name	1941	1946	1956	1970	1991	1995	1996	2013 LW	2013 NS
Star duckweed	*Lemna trisulca*		X						1	2
Greater duckweed	*Spirodela polyhriza*							R	1	6
	Total	0	1	0	0	0	0	1	2	2

I = introduced

P= present in lake but not found during the lakewide survey

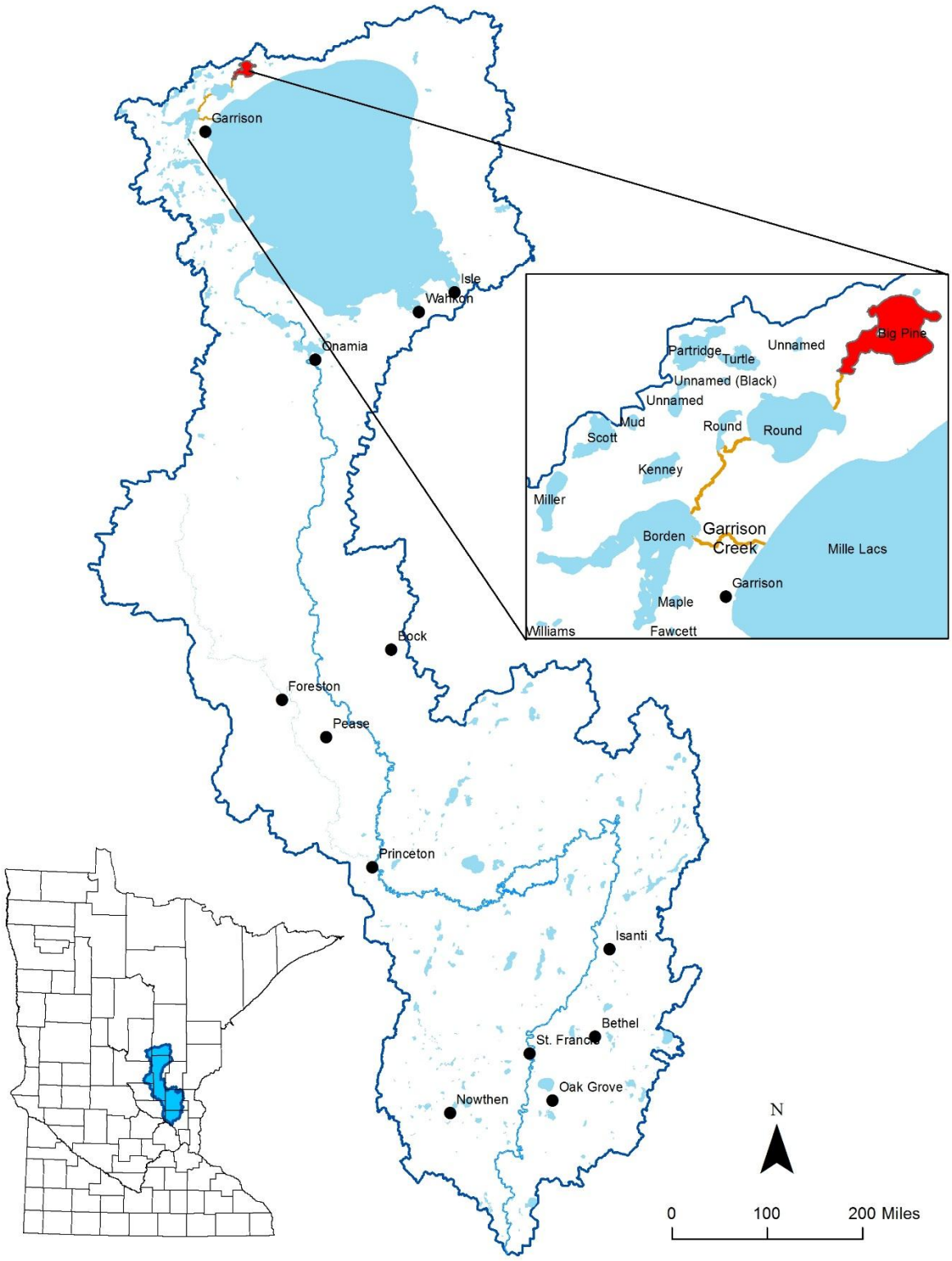
1941 (July 30 and August 2) – MN Dept. of Conservation, Division of Game and Fish, Bureau of Fisheries Research
1946 (August 26-28) – MNDNR Fisheries
1956 (June 20-23) – MNDNR Fisheries 1971 (August 26) – MNDNR Fisheries 1991(August 26-30) –MNDNR Fisheries
1995 (August 9) – MNDNR Minnesota Biological Survey
1996 (August 26) – MNDNR Fisheries
2013 (August 12-14, 22, 28) – MNDNR EWR Division – Lake Habitat Program
LW = lakewide
NS = nearshore

Table 5: Historic and current plants of Big Pine Lake (continued)

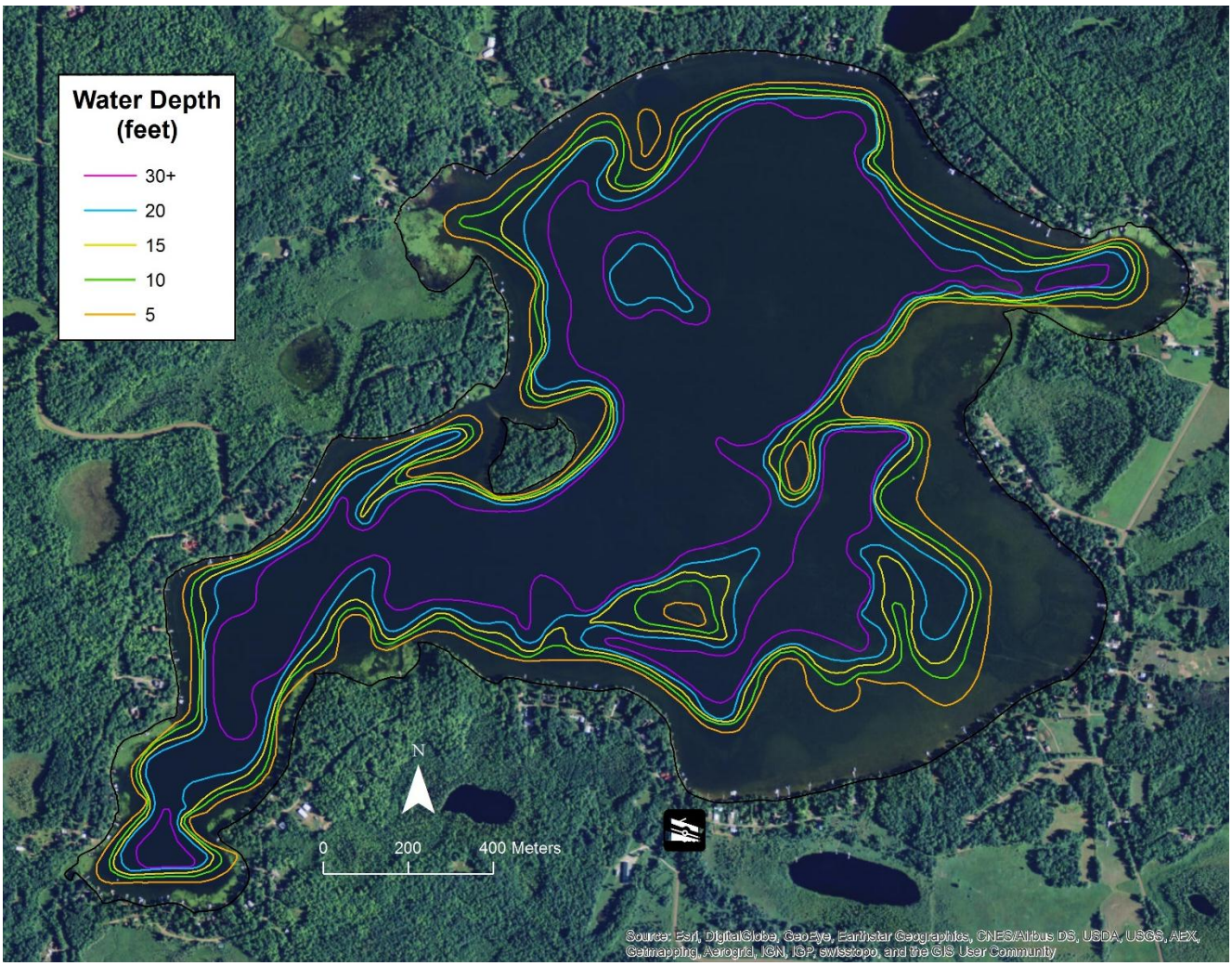
Submerged plants

	Common Name	Scientific Name	1941	1946	1956	1970	1991	1995	1996	2013 LW	2013 NS
Large Algae	Muskgrass	*Chara* sp.		X	C		A		C	39	19
	Stonewort	*Nitella* sp.							R	<1	--
Monocots	Needlegrass	*Eleocharis acicularis*						X	R	<1	6
	Canada waterweed	*Elodea canadensis*		X					R	6	8
	Water star-grass	*Heteranthera dubia*						X		4	27
	Quillwort	*Isoetes* sp.							R	1	--
	Bushy pondweed	*Najas flexilis*		X			C	X	C	14	58
	Southern naiad	*Najas guadalupensis*								7	--
	Large-leaf pondweed	*Potamogeton amplifolius*		X			O	X	R	7	--
	Curly-leaf pondweed (I)	*Potamogeton crispus*				O	R		R	<1	--
	Fries' pondweed	*Potamogeton friesii*		X			O	X	R	31	17
	Small pondweed	*Potamogeton pusillus*						X			
	Variable pondweed	*Potamogeton gramineus*		X			C		C	14	19
	Illinois pondweed	*Potamogeton illinoensis*					O		R	7	--
	White-stem pondweed	*Potamogeton praelongus*					O		R	3	--
	Clasping-leaf pondweed	*Potamogeton richardsonii*	A	X		O	C	X	C	20	2
	Robbins' pondweed	*Potamogeton robbinsii*						X	R	14	2
	Flat-stem pondweed	*Potamogeton zosteriformis*		X			A	X	C	36	6
	Sago pondweed	*Stuckenia pectinata*	A	X			R	X	R	5	23
Dicots	Water marigold	*Bidens beckii*						X	R	3	2
	Coontail	*Ceratophyllum demersum*		X	C	C		X	C	37	31
	Northern watermilfoil	*Myriophyllum sibiricum*	A	X	C	C	A	X	C	36	15
	Leaf-less watermilfoil	*Myriophyllum tenellum*							R	--	--
	White-water buttercup	*Ranunculus aquatilis*		X						2	8
	Creeping spearwort	*Ranunculus flammula*						X		<1	--
	Greater bladderwort	*Utricularia vulgaris*					P			1	2
	Wild celery	*Vallisneria americana*	A	X			C	X	C	24	4
		Total	4	12	3	4	2	15	22	25	17

Map 1. Big Pine Lake within the Rum River watershed



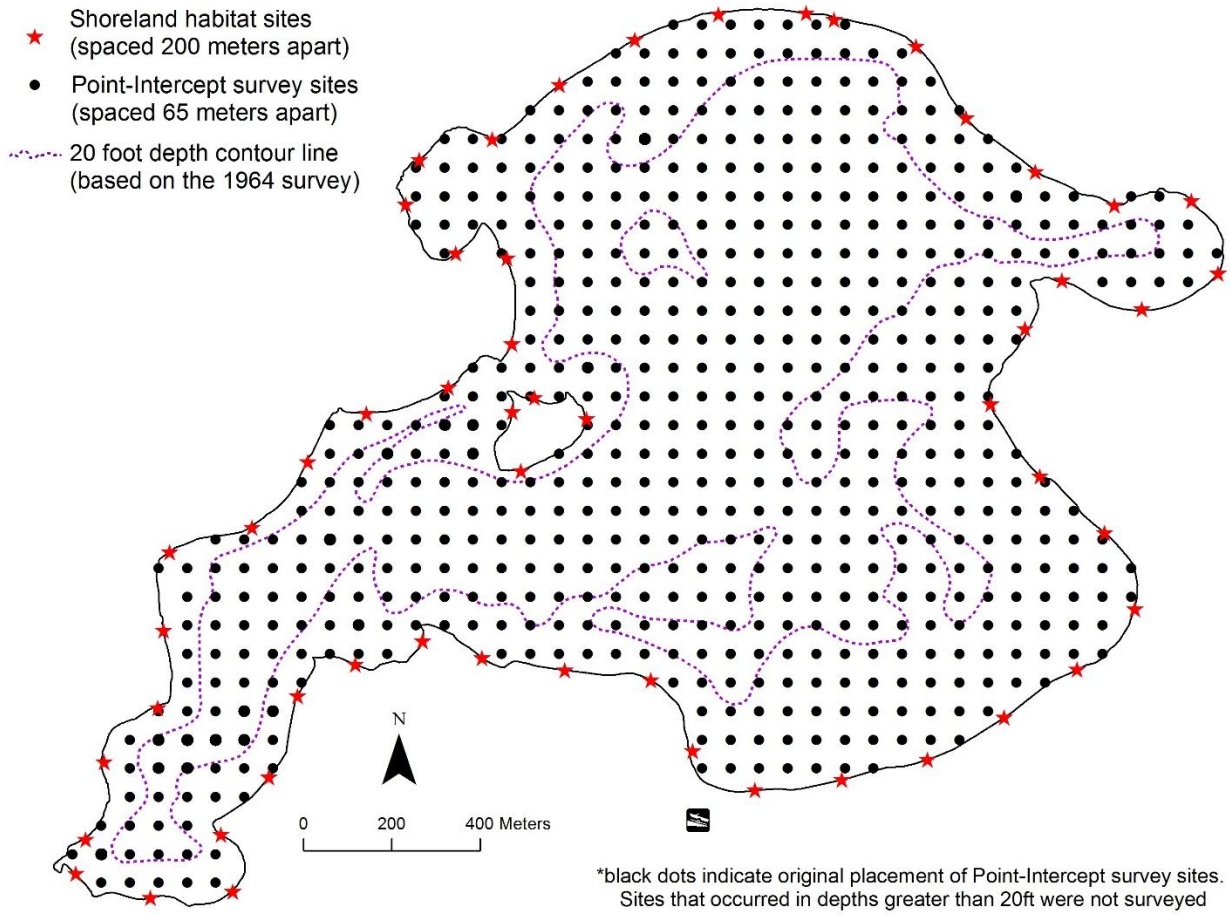
Map 2. Water depth contours of Big Pine Lake.



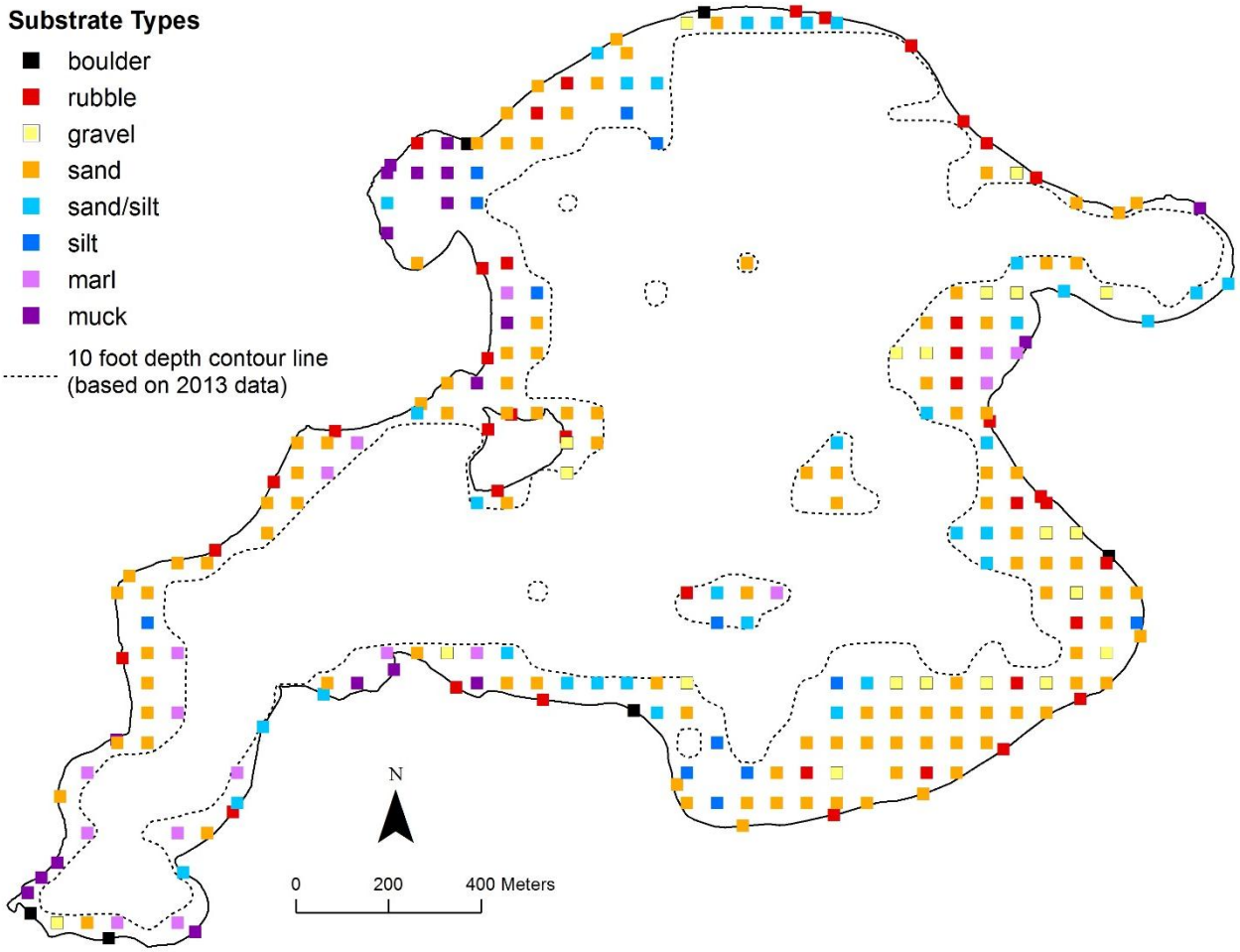
*Depth contours were based on the 1964 survey.

Imagery: ESRI World Imagery

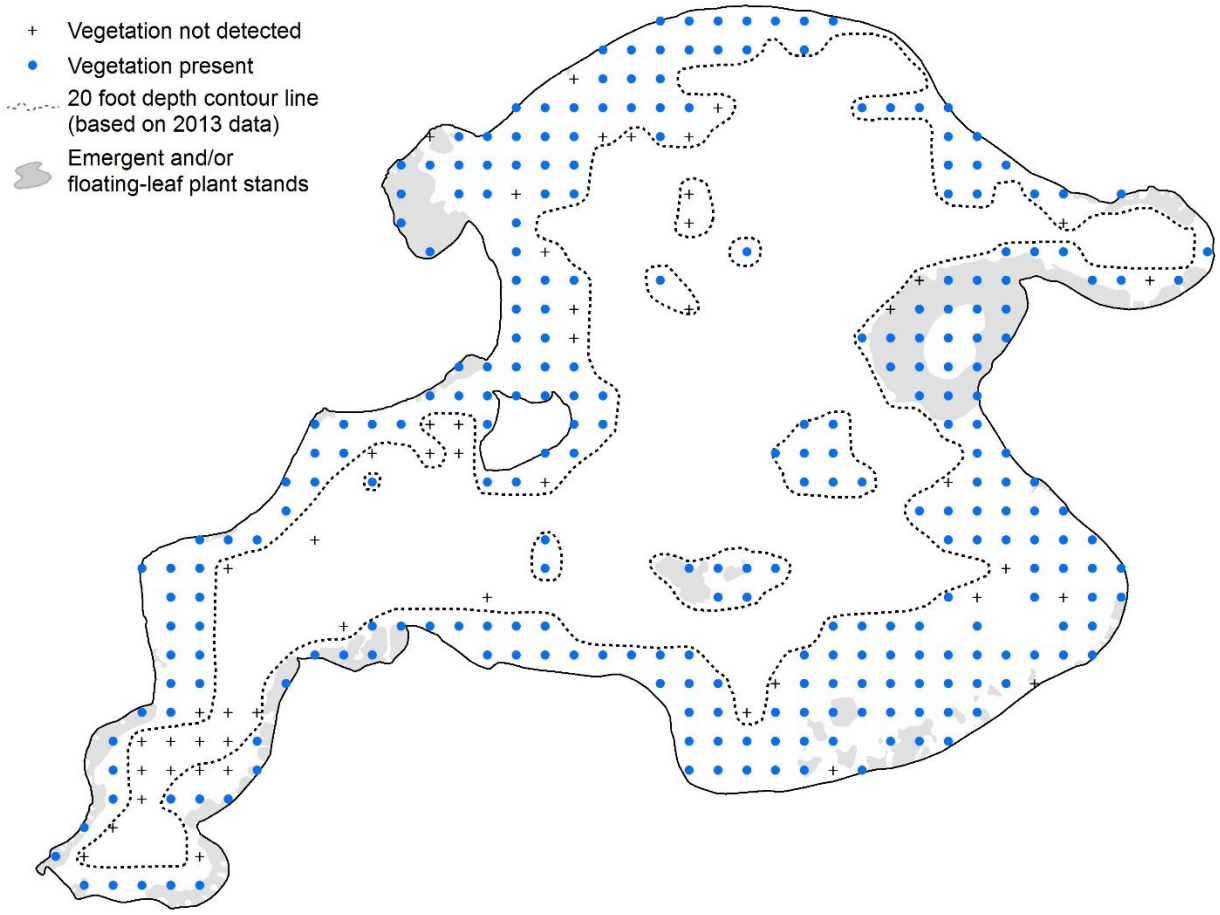
Map 3. Vegetation survey sites in Big Pine Lake, 2013.



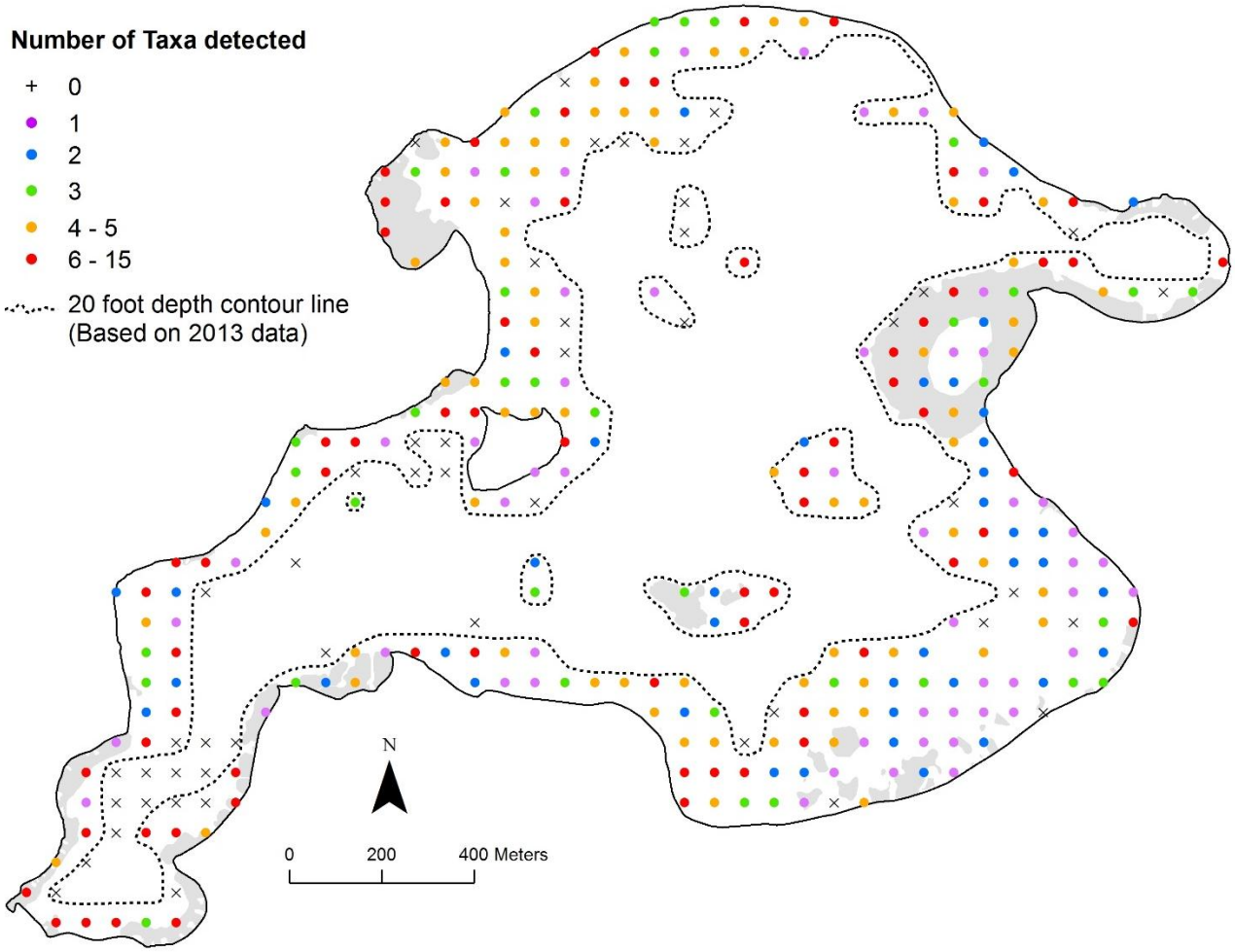
Map 4. Nearshore substrates of Big Pine Lake, 2013.



Map 5. Aquatic vegetation present at sample sites, Big Pine Lake, 2013.



Map 6. Number of taxa per sample site, Big Pine Lake, 2013.



Map 7. Emergent and Floating-leaf plant stands, Big Pine Lake, 2013.